Evaluation of the Effectiveness of Alternative Fast Pass, Fast Fail, and Retest Algorithms in the Phoenix IM147 Program

Final Report to the Arizona Department of Environmental Quality

October 16, 2000

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Executive Summary

This report compares the current method of quickly identifying passing and failing vehicles in the Phoenix IM147 program ("the Sierra method") with an alternative method developed by the Arizona Department of Environmental Quality ("the DEQ method"). There are several limitations with the database of over 30,000 vehicles provided to us to make the comparison; therefore our results should be considered estimates of the relative effectiveness of the two methods.

The DEQ method results in a slightly lower failure rate, and a slightly longer average test time, than the Sierra method, when applied to all vehicles that would complete testing under the DEQ method. To estimate the number of false passes and failures, and the fraction of total excess emissions identified under each method, we use a subset of 1,775 vehicles for which a full IM147 test (three full traces) is available. The DEQ method results in a much lower false fail rate, and identification of more excess CO emissions, than the Sierra method when applied to this subset of vehicles. On the other hand, the Sierra method results in a slightly lower false pass rate, identification of more excess HC and NOx emissions, and a shorter test time than the DEQ method. The relative effectiveness of each method is consistent whether the cut points currently in use in the Phoenix program, or more stringent cut points developed by EEA, are applied.

Introduction

In this report we analyze the effectiveness of two different methods to quickly identify passing and failing vehicles in the Phoenix IM147 program: a method developed by Sierra Research, which is currently in place in the Phoenix program ("the Sierra method"), and an alternative method developed by staff of the Arizona Department of Environmental Quality ("the DEQ method"). The IM147 test involves up to three 147-second traces; vehicles that are suspected of not being properly pre-conditioned (i.e. warmed up) prior to testing are tested over up to three traces, to reduce the number of normal-emitting vehicles that may be failed simply because they were not properly pre-conditioned.

Each of the two methods was developed using a database of 3,347 vehicles given triplicate 147-second traces. Each method involves application of a fast pass algorithm in which vehicles with low emissions pass the test prior to completion of a full 147-second trace; a fast fail algorithm, in which vehicles with high emissions fail the test prior to completion of a full 147-second trace; and a retest algorithm, which determines which vehicles that fail a previous trace are allowed a subsequent trace in which to pass.

There are three general measures of the effectiveness of each method:

1) how many vehicles are falsely fast-passed, and what percentage of total excess emissions are therefore lost;
2) how many vehicles are falsely fast-failed;
3) how long the test takes on average.

The number of vehicles that are falsely passed, and the fraction of total excess emissions not identified, reduces the effectiveness of the program in reducing emissions from vehicles. The number of vehicles that are falsely failed requires owners to attempt repairs that are unnecessary, and can lead to public frustration with the program. If the program takes too long to test vehicles, particularly clean vehicles, the result can also be public frustration with the program. There are general tradeoffs with each of these three measures of program effectiveness; algorithms developed to eliminate or dramatically reduce the number of false passes will likely result in a relatively higher number of false failures, and vice versa. And finely tuning test algorithms to reduce both false passes and false failures will tend to increase test times. Ultimately the DEQ must determine which of the three measures of program effectiveness to optimize in developing their test program. Historically DEQ has been more concerned about reducing the number of false failures than reducing the number of false passes.

To determine accuracy of fast-pass, fast-fail, and retest algorithms requires a relative large sample of vehicles given three full IM147 traces sequentially. However, the data Gordon-Darby provided for this analysis fails to meet these objectives. Therefore our results should be viewed as only estimates of the relative accuracy of each two methods. We note in our report how our estimates may be biased by the limitations of the data available to us for this study.

In the next sections we briefly describe the Sierra and DEQ methods and the data used to compare the two methods. Then we compare failure rates and test times for a random sample of vehicles under each method. Finally we examine a subset of vehicles to estimate the number of false passes, false fails, and excess emissions identified under each method. We conduct both analyses using both the cut points currently in place in the Phoenix program, and an alternative set of more stringent cut points.

Methods Analyzed

The Sierra method utilizes regression coefficients derived from the absolute emissions produced in each of 20 segments of the IM147 driving cycle. Sierra's coefficients vary by individual cycle segment and vehicle type, and by model year group. Full-test emissions are projected after each cycle segment; if the projected emissions plus an error term are below the specified cut point, the vehicle is fast-passed. Fast-pass begins after segment 2 of each trace. A vehicle cannot fail until after completing the first trace. A failing vehicle receives a second trace (retest) if its segment 7 or segment 19 emissions are within a specified range above the cut point or HC or CO emissions are decreasing between segments 7 and 19. A failing vehicle receives a retest only if it meets the retest criteria for each of the three pollutants. A vehicle may fast-fail after segment 7 only in the second trace, and after segment 7 or any subsequent segment in the third trace. The fast-fail algorithm utilizes the predicted emissions at each segment; if the predicted emissions exceed the cut point plus a specified range for any pollutant the vehicle fast fails.

The DEQ method uses two sets of regression coefficients derived from the cumulative emissions after each of the 20 segments. There are separate coefficients to determine fast-pass and fast-fail, with the coefficients at each segment converging until they meet at segment 20. Like Sierra's coefficients, the DEQ coefficients vary by individual cycle segment and vehicle type, as well as by individual model year. Under the DEQ method a vehicle can fast-pass after segment 2

or any subsequent segment on each trace. A vehicle can be fast-failed after segment 14 or any subsequent segment of the initial trace, or any segment after segment 2 in the second or third traces. All vehicles failing trace 1 receive a retest; if a vehicle's emissions exceed the cut point plus a specified range for any pollutant, or if emissions have decreased beyond a threshold level between segment 2 of trace 1 and trace 2, fast-fail is enabled for trace 2. If these conditions are not met, the vehicle cannot fail during trace 2, but must receive a full second trace. A vehicle can fast-pass in trace 2 at any time after segment 2, regardless of whether it meets the requirements for a third trace. A vehicle can fast fail after any segment after segment 2 in trace 3.

We compared the two methods under two sets of cut points, the current cut points used in the program and more stringent cut points developed for the DEQ by Energy and Environmental Associates (EEA). We expect that use of the EEA cut points will improve the performance of the DEQ method relative to the Sierra method, as the DEQ algorithms were developed based on the EEA cut points.

Data Used

Gordon-Darby provided a sample of IM147 tests of 30,638 vehicles. This sample was randomly selected from vehicles reporting for IM147 testing, and represents about half of the vehicles reporting from June 8, 2000 through July 18, 2000. Gordon-Darby applied tighter cut points than those currently in place in the program in order to test vehicles over a longer portion of the complete IM147 test than they otherwise would have been. The final trace of each test, by which the pass/fail result is determined, is identified in the data. However, some vehicles have more than one final trace; for example, some vehicles have a total of three traces, two of which are coded as final traces. Presumably these subsequent final traces are IM147 tests conducted after repairs were made to the vehicles, although some of the vehicles passed initial testing. In our analysis we only examine the first final trace for each vehicle in the database.

To determine the accuracy of fast-pass, fast-fail, and retest algorithms requires a relatively large sample of vehicles given three full IM147 traces sequentially. DEQ requested such a sample from Gordon-Darby. However, the data Gordon-Darby provided fails to meet these objectives. First, a large fraction of vehicles (13,046, or 43%) are fast-passed on their initial IM147 trace. This means we cannot determine how many of these vehicles were falsely fast-passed (i.e., would have had cumulative emissions higher than the cut point if allowed to continue over the entire test.). Second, of the vehicles not fast-passed on their initial trace, very few (16) are given a full 147-second test; the initial trace of the remaining 17,696 vehicles is truncated after segment 19 (second 132), prior to the final deceleration in the driving trace. Of the 3,807 vehicles receiving a third trace, 1,254 (33%) are tested for the full 147 seconds (and an additional 527 are tested for 132 seconds). For our analyses we treat all vehicles tested for 132 seconds or longer as having received a full 147-second trace. Third, only a small number of vehicles (1,775) received a sequence of three "full" IM147 traces. Three full traces are necessary to assess the accuracy of each method in properly identified passing and failing vehicles, and the fraction of excess emissions captured by each method.

In the next section we compare the overall test results and test times, including fast-pass, fast-fail, and retest algorithms, for each method, using the cut points currently in force in the Phoenix program and the more stringent EEA cut points. Then we compare the false pass and false fail rates, as well as the fraction of excess emissions identified, under each method, using the subset of 1,775 vehicles that are given three "full" 132-second traces, under current and EEA cut points. Detailed tables of results by vehicle type and individual model year are presented in an Appendix.

Overall Test Results

The overall failure rate of the vehicles is 18.8%, using the more stringent cut points Gordon-Darby applied. Table 1 shows the number of vehicles, fail rate, and average test time by vehicle type, both as reported by Gordon-Darby using the more stringent study cut points and as calculated using the cut points currently in place in Phoenix. When we apply the Sierra method and the more lenient current cut points to the complete data set, we obtain an overall failure rate of only 17.1% (the total number of vehicles tested changes slightly as 6 vehicles were fast-failed under the Gordon-Darby cut points prior to completing testing under the current cut points). Average test time is reduced, from 164 seconds to 106 seconds, as more vehicles are fast-passing the more lenient cut points. (Table A-1 in the Appendix shows the results of Table 1 by vehicle type and individual model year.)

Table 1. Number of Vehicles, Fail Rates and Average Test Times by Vehicle Type. Gordon-Darby Study and Current Cut Points

Vehicle Type	Gordon-Darby + Study Cut Points			Gordon-Darby + Current Cut Points		
	Number	Fail Rate	Average Test Time	Number	Fail Rate	Average Test Time
LDT2	2,864	16.6%	160.7	2,864	14.9%	91.4
LDT1	9,056	19.4%	153.0	9,055	17.7%	92.5
Car	18,718	18.8%	169.5	18,713	17.1%	114.3
Total	30,638	18.8%	163.8	30,632	17.1%	105.7

When we apply the DEQ method and the current cut points to the complete data set, we obtain an overall failure rate of only 7.6%, as shown in the upper right-hand panel of Table 2. Part of the discrepancy between failure rates under the two methods is because the Sierra method ends the test for a large number of vehicles (5,678 or 19%) before the test is ended under the DEQ method. (Of these vehicles, 2,740 or 48% fail current cut points under the Sierra method.) To account for this, we compared the results using the DEQ method to the results using the Sierra method on the same subset of vehicles; this comparison is shown in Table 2, using both current cut points and the more stringent EEA cut points.

Table 2. Number of Vehicles, Fail Rates and Average Test Times by Vehicle Type, Method, and Cut Points

Cut Points	Vehicle Type	Sierra			DEQ		
		Number	Fail Rate	Average Test Time	Number	Fail Rate	Average Test Time
Current	LDT2	2,561	8.3%	81.1	2,561	5.9%	86.3
	LDT1	7,537	11.7%	81.5	7,537	9.1%	88.4
	Car	14,856	9.4%	101.8	14,856	7.2%	108.6
	Total	24,954	10.0%	93.5	24,954	7.6%	100.2
EEA	LDT2	2,246	12.7%	94.6	2,246	7.9%	97.0
	LDT1	6,596	25.1%	98.9	6,596	15.3%	104.4
	Car	12,847	15.8%	111.5	12,847	11.1%	118.3
	Total	21,689	18.4%	105.9	21,689	12.0%	111.9

The top panels of Table 2 indicate that the DEQ method results in a lower overall failure rate than the Sierra method, 7.6% as opposed to 10.0%, when the same cut points are applied and the sample is restricted only to vehicles that complete the DEQ test method. Under each method the failure rate is higher for LDT1s, and lower for LDT2s, than for passenger cars. The Sierra method takes slightly less time than the DEQ method: 94 seconds on average as opposed to 100 seconds.

Application of the EEA cut points lowers the total number of vehicles tested by 14%. Because the EEA cut points are more stringent, it takes the average vehicle more time to fast-pass; as a result, many vehicles do not fast-pass by the time Gordon-Darby ended the test under their study cut points. The EEA cut points do not change the performance of the DEQ method relative to the Sierra method; the DEQ method still results in a lower failure rate, and a longer average test time, than the Sierra method. The EEA cut points increase the failure rates under each method: from 10.0% to 18.4% under the Sierra method, and from 7.6% to 12.0% under the DEQ method. Average test time also increases, from 94 seconds to 106 seconds under the Sierra method and from 100 seconds to 112 seconds under the DEQ method. (Tables A-2 and A-3 in the Appendix show the results of Table 2 by vehicle type and individual model year.)

False Test Results

In order to assess the number of false passes and fails under each method, we use a subsample of 1,778 vehicles which received a "full" IM147 trace for each trace required under each method (that is, if either method require a second or third trace, we only included those vehicles that were actually tested for 132 seconds or longer on their second or third trace). If a vehicle passed any of the three traces, we counted that vehicle as a passing vehicle, even if it received a subsequent trace because of the stringent cut points Gordon-Darby used to generate the data. We note that this is not a random sample of vehicles; these vehicles are likely to be marginal emitters, in that they did not have emissions low enough to be fast-passed, or high enough to be fast-failed, on their initial IM147 trace. On the other hand, because Gordon-Darby used a combination of relatively stringent cut points in collecting these data, a larger percentage of vehicles received at least one "full" IM147 trace than would have if the current cut points were applied.

Table 3 shows the number of vehicles, fail rates, average test times, and excess emissions identified, by vehicle type and method, for this subset of vehicles. The actual fail rate is based on the reported emissions at second 132 divided by the reported miles driven at second 132; false pass and fail rates are determined by comparing the test result under each method to the actual fail rate. We express false pass and false fail rates in two different ways; first as a percentage of all tests (all false passes or all false fails divided by all tests) and then as a percentage of all actual fails or all actual passes (all false passes divided by all actual fails, all false fails divided by all actual passes). To calculate excess emissions, we use the cumulative emissions after second 132 (segment 19) divided by the recorded vehicle miles traveled, less the appropriate grams per mile cut point (in Table 3 we use the current cut points; results using EEA cut points are presented in Table 5 and discussed below). The excess emissions identified are the fraction of total excess emissions from vehicles that are failed under each method.

Table 3 indicates that the Sierra method fails the same number of vehicles as actually fail current cut points; the Sierra fail rate is 12.6% as opposed to the actual fail rate of 12.8%. However, the Sierra method falsely passes 96 vehicles, and falsely fails another 92 vehicles. This results in roughly similar false pass (5.4%) and false fail (5.2%) rates of all tested vehicles. The 96 falsely passed vehicles amount to 42% of all actual failures; this means that the Sierra method incorrectly passes nearly half of the vehicles that actually failed testing. The DEQ method results in a lower overall failure rate (5.7%) a higher false pass rate (7.7%), and a much lower false fail rate (0.6%) than the Sierra method. The fail rate under the DEQ method is lower than the actual fail rate because the method is falsely passing a relatively large number of vehicles (136); the DEQ method incorrectly passes 60% of the vehicles that actually failed testing. However, it should be noted that the DEQ method misidentifies (either false passes or false fails) fewer vehicles than the Sierra method (146 vs. 188). And the DEQ method falsely fails only 10 vehicles. Under each method the false pass rate is slightly lower for LDT2s and higher for passenger cars. Vehicles that actually failed for NOx only or CO only (based on their composite emissions after segment 19, or second 132) account for over 90% of the vehicles falsely fast-passed under each method.

The false pass rates are relatively high under each method in part because the subset of vehicles used in this analysis is biased. Because only vehicles that require three full IM147 traces can be analyzed, a large number of vehicles with extremely low emissions, and a low probability of being falsely passed, have been fast-passed by Gordon-Darby, and therefore excluded from the analysis. Similarly a small number of vehicles with extremely high emissions have been fast-failed, and also excluded. The remaining vehicles have emissions relatively close to the cut points Gordon-Darby used, and therefore likely higher than the emissions of a truly random sample of vehicles.

The Sierra method only identifies 86% of excess HC, 45% of excess CO, and 67% of excess NOx. The DEQ method identifies about the same portion of excess HC (81%), more excess CO (58%), but less of the excess NOx (39%). The average test time under the Sierra method (197 seconds) is substantially shorter than the average test time under the DEQ method (221 seconds). (Tables A-4 and A-5 in the Appendix show the results of Table 3 by vehicle type and individual model year.)

Table 3. Fail Rates, Average Test Times, and Excess Emissions Identified by Vehicle Type and Method, using Current Cut Points and Actual VMT. Based on vehicles given three full IM147 traces.

Method	Vehicle Type	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Average Test Time	Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
Sierra	LDT2	170	6.5%	6.5%	4.1%	64%	4.1%	4.4%	154.0	NA	29%	0%
	LDT1	433	10.9%	11.8%	5.1%	47%	6.0%	6.7%	161.5	100%	12%	58%
	Car	1,172	14.4%	13.7%	5.7%	40%	5.0%	5.9%	215.5	86%	56%	75%
	Total	1,775	12.8%	12.6%	5.4%	42%	5.2%	5.9%	196.5	86%	45%	67%
DEQ	LDT2	170	6.5%	1.8%	5.3%	82%	0.6%	0.6%	151.4	NA	27%	0%
	LDT1	433	10.9%	3.9%	6.9%	64%	0.0%	NA	201.6	0%	58%	48%
	Car	1,172	14.4%	6.9%	8.3%	57%	0.8%	0.9%	237.7	86%	65%	35%
	Total	1,775	12.8%	5.7%	7.7%	60%	0.6%	0.6%	220.6	81%	58%	39%

Because nearly all of these vehicles are only tested for 132 seconds on each trace, the false pass rates shown in Table 3 may be overstated. The last segment of the IM147 (seconds 133 through 147) is a deceleration over one-tenth of a mile, which likely results in very low emissions, and low gram per mile emissions relative to other segments of the trace, for most vehicles. For most vehicles gram per mile emissions at second 132 are higher than over a full 147-second test; when we compare these higher gram per mile emissions to the gram per mile cut points, we may be overstating the number of vehicles that would fail a full 147-second trace. We estimate the minimum false pass and false fail rates by dividing emissions at 132 seconds by the full test distance, 1.4 miles, rather than by the actual distance driven by each vehicle after 132 seconds. Table 4 indicates that using 1.4 miles rather than actual miles to determine the full test result lowers actual fail rates and false pass rates, and increases false fail rates and excess emissions identified, under each method. However, the Sierra method still results in a lower false pass rate and more excess CO identified than the DEQ method, while the DEQ method still results in a much lower false fail rate and more excess NOx identified than the Sierra method. (Tables A-6 and A-7 in the Appendix show the results of Table 4 by vehicle type and individual model year.)

Table 4. Fail Rates, Average Test Times, and Excess Emissions Identified by Vehicle Type and Method, using Current Cut Points and 1.4 Miles. Based on vehicles given three full IM147 traces.

Method	Vehicle Type	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Average Test Time	Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
Sierra	LDT2	170	4.1%	6.5%	2.4%	57%	4.7%	4.9%	154.0	NA	47%	0%
	LDT1	433	7.6%	11.8%	2.8%	36%	6.9%	7.5%	161.5	NA	22%	69%
	Car	1,172	10.9%	13.7%	3.0%	27%	5.8%	6.5%	215.5	100%	62%	88%
	Total	1,775	9.5%	12.6%	2.9%	30%	6.0%	6.6%	196.5	100%	57%	80%
DEQ	LDT2	170	4.1%	1.8%	3.5%	86%	1.2%	1.2%	151.4	NA	30%	0%
	LDT1	433	7.6%	3.9%	3.7%	48%	0.0%	NA	201.6	NA	78%	65%
	Car	1,172	10.9%	6.9%	4.9%	45%	0.9%	1.1%	237.7	100%	76%	54%
	Total	1,775	9.5%	5.7%	4.5%	48%	0.7%	0.8%	220.6	100%	67%	58%

Tables 5 and 6 present fail rates, average test time, and excess emissions identified when EEA cut points are used rather than the current program cut points. Table 5 uses actual miles driven to determine the full test result, while Table 6 uses 1.4 miles to determine the full test result.

Table 5 indicates that actual fail rates and fail rates under each method increase substantially when we apply EEA cut points, compared to the results using current cut points, as shown in Table 3; the actual fail rate increases to 43%, the Sierra fail rate increases to 42%, and the DEQ fail rate increases to 27%. False pass rates also increase dramatically, to 7.3% of all vehicles under the Sierra method and to 16.6% of all vehicles under the DEQ method. The rate of false fails as a percent of all vehicles are similar to those using current cut points. Average test time also increases, from 197 seconds to 217 seconds under the Sierra method, and from 221 seconds to 268 seconds under the DEQ method. Both methods identify a larger fraction of the emissions in excess of the EEA cut points than in excess of the current cut points, particularly NOx emissions.

We anticipated that the performance of the DEQ method relative to the Sierra method would improve when we apply the EEA cut points. The DEQ method does continue to result in very low false fail rates with the EEA cut points. And the DEQ method results in much fewer test errors than the Sierra method (93 vs. 157). However, as with the current cut points, the DEQ method results in a higher false pass rate, less excess emissions identified, and longer average test times than the Sierra method. (Tables A-8 and A-9 in the Appendix show the results of Table 5 by vehicle type and individual model year.)

Table 5. Fail Rates, Average Test Times, and Excess Emissions Identified by Vehicle Type and Method, using EEA Cut Points and Actual VMT. Based on vehicles given three full IM147 traces.

Method	Vehicle Type	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Average Test Time	Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
Sierra	LDT2	170	25.3%	24.7%	10.0%	40%	9.4%	12.6%	206.9	70%	75%	76%
	LDT1	433	58.0%	55.7%	11.3%	20%	9.0%	21.4%	212.0	99%	65%	90%
	Car	1,175	40.2%	39.5%	5.4%	13%	4.7%	7.8%	220.3	90%	61%	96%
	Total	1,778	43.1%	42.0%	7.3%	17%	6.2%	10.9%	217.0	89%	67%	93%
DEQ	LDT2	170	25.3%	12.4%	13.5%	53%	0.6%	0.8%	190.6	77%	84%	37%
	LDT1	433	58.0%	33.9%	24.7%	43%	0.7%	1.6%	277.7	77%	63%	72%
	Car	1,175	40.2%	26.7%	14.0%	35%	0.6%	1.0%	275.5	100%	53%	77%
	Total	1,778	43.1%	27.1%	16.6%	39%	0.6%	1.1%	267.9	82%	66%	74%

Table 6 shows the effect of using 1.4 miles rather than the recorded mileage to determine the actual test result under EEA cut points. Again, use of EEA cut points does not change the effectiveness of the DEQ method relative to that of the Sierra method. (Tables A-10 and A-11 in the Appendix show the results of Table 6 by vehicle type and individual model year.)

Table 6. Fail Rates, Average Test Times, and Excess Emissions Identified by Vehicle Type and Method, using EEA Cut Points and 1.4 Miles. Based on vehicles given three full IM147 traces.

Method	Vehicle Type	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Average Test Time	Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
Sierra	LDT2	170	20.0%	24.7%	5.3%	26%	10.0%	12.5%	206.9	75%	80%	89%
	LDT1	433	51.5%	55.7%	5.8%	11%	9.9%	20.5%	212.0	100%	74%	92%
	Car	1,175	36.8%	39.5%	3.4%	9%	6.1%	9.7%	220.3	90%	72%	97%
	Total	1,778	38.8%	42.0%	4.2%	11%	7.4%	12.1%	217.0	91%	76%	95%
DEQ	LDT2	170	20.0%	12.4%	8.2%	41%	0.6%	0.7%	190.6	87%	86%	45%
	LDT1	433	51.5%	33.9%	18.5%	36%	0.9%	1.9%	277.7	78%	72%	75%
	Car	1,175	36.8%	26.7%	10.9%	30%	0.9%	1.3%	275.5	100%	57%	79%
	Total	1,778	38.8%	27.1%	12.5%	32%	0.8%	1.4%	267.9	85%	72%	77%

Summary

This analysis found that the DEQ method to quickly determine whether a vehicle will pass or fail the IM147 test results in a much lower false fail rate than the Sierra method, and in some cases identifies a larger portion of excess CO emissions. On the other hand, the DEQ method results in fewer overall failures and a higher false pass rate, longer average test time, and less excess HC and NOx identified than the Sierra method. These results are consistent whether current cut points or more stringent EEA cut points are applied.

Our estimates of false pass and false fail rates are likely overstated, and our estimates of excess emissions identified likely understated, because the sample of full test vehicles available for this analysis is biased. Nearly half of the vehicles in the entire sample were fast-passed on their initial trace; without a measurement of the full test emissions of these vehicles we cannot fully assess the accuracy of the fast-pass algorithm under each method. To fully assess the accuracy of each fast-pass algorithm, we require a random sample of vehicles with fast-pass turned off for at least the first IM147 trace, and preferably for three full IM147 traces.

As an alternative to collecting more data, we recommend analyzing IM147 emissions from second-by-second IM240 data already collected by Gordon-Darby. The first 94 seconds of the IM240 data can be discarded, and the remaining data can be used to estimate the false pass rate over a single, full IM147 trace, with the understanding that these vehicles likely are better preconditioned than the vehicles reporting for I/M testing (since all of them were driven over the first 94 seconds of the IM240 prior to the "start" of the IM147).

In the course of this analysis we identified clear flaws in the DEQ method. For instance, the criteria for fast passing 1995 cars after segment 2 (second 16) for CO is extremely lenient; whereas 1994 and 1996 cars must have cumulative CO emissions of less than 0.3 grams after segment 2 in order to fast-pass, 1995 cars can be fast passed with cumulative CO emissions of up to 1.9 grams after segment 2. This lenient fast pass criterion is likely the result of too few vehicles of a particular type and model year in the 3,347 vehicle database DEQ used to develop their fast pass algorithm.

Appendix: Tables of Results by Vehicle Type and Individual Model Year

Table A-1. Number of Vehicles, Fail Rate, and Average Test Time by Type and Model Year. Gordon-Darby Study and Current Cut Points.

Vehicle Type	Model Year	Gordon-Darby + study cut points			Gordon-Darby + current cut points		
		Number	Fail Rate	Avg Test Time	Number	Fail Rate	Avg Test Time
LDT2	1981	27	70%	238.1	27	56%	168.3
	1982	31	65%	200.8	31	61%	145.0
	1983	58	60%	229.0	58	53%	174.1
	1984	75	57%	223.7	75	55%	169.8
	1985	108	49%	198.7	108	44%	131.4
	1986	102	54%	195.9	102	47%	136.5
	1987	96	28%	217.7	96	22%	103.1
	1988	151	28%	222.6	151	22%	107.2
	1989	156	21%	203.0	156	15%	81.6
	1990	148	19%	202.2	148	12%	96.4
	1991	145	10%	190.7	145	8%	86.1
	1992	189	12%	190.4	189	8%	91.0
	1993	241	7%	176.1	241	6%	70.5
	1994	391	5%	130.5	391	6%	87.3
	1995	809	6%	121.4	809	8%	80.5
	1996	45	4%	51.0	45	2%	28.5
	1997	39	0%	27.4	39	0%	16.0
	1998	25	0%	25.4	25	0%	16.7
	1999	21	0%	22.2	21	0%	16.0
	2000	7	0%	18.6	7	0%	16.0
LDT1	1981	91	65%	232.6	91	55%	144.2
	1982	88	63%	221.3	88	55%	148.4
	1983	139	62%	232.5	139	52%	150.7
	1984	241	52%	223.3	241	44%	141.2
	1985	309	46%	201.3	309	38%	118.9
	1986	460	47%	200.2	460	39%	129.7
	1987	473	35%	193.0	473	30%	118.8
	1988	530	26%	180.4	530	24%	103.1
	1989	558	18%	165.2	558	17%	101.3
	1990	511	24%	190.1	511	21%	108.4
	1991	699	18%	172.3	699	15%	100.3
	1992	666	14%	163.6	666	12%	85.3
	1993	920	11%	155.8	920	10%	81.5
	1994	1,080	9%	118.7	1,080	11%	80.2
	1995	2,056	6%	106.6	2,055	8%	70.0
	1996	75	4%	45.2	75	3%	24.2
	1997	67	1%	30.2	67	1%	21.1
	1998	53	0%	34.8	53	0%	21.5
	1999	28	4%	24.1	28	4%	21.3
	2000	12	0%	19.0	12	0%	16.0
Car	1981	139	58%	251.7	139	50%	163.2
	1982	164	52%	250.5	164	45%	157.3
	1983	294	53%	248.7	294	47%	147.1
	1984	444	51%	257.3	444	42%	145.5
	1985	610	45%	247.3	610	36%	132.6
	1986	779	42%	213.1	779	37%	146.0
	1987	955	39%	211.6	955	34%	140.5
	1988	1,084	32%	206.0	1,084	27%	135.4
	1989	1,314	24%	199.6	1,314	21%	130.2
	1990	1,268	27%	191.5	1,268	26%	140.0
	1991	1,443	20%	187.5	1,443	19%	129.6
	1992	1,587	12%	170.0	1,587	12%	119.0
	1993	1,877	10%	159.2	1,877	9%	110.1
	1994	2,072	7%	147.4	2,071	10%	106.7
	1995	4,147	4%	118.4	4,143	4%	81.6
	1996	189	2%	68.6	189	2%	41.9
	1997	139	3%	50.8	139	2%	27.3
	1998	109	1%	35.0	109	0%	22.3
	1999	83	0%	29.7	83	0%	21.6
	2000	21	0%	19.0	21	0%	16.0
Total		30,638	18.8%	163.8	30,632	17.1%	105.7

Table A-2. Number of Vehicles, Fail Rate, and Average Test Time by Type and Model Year. Sierra and DEQ Methods using Current Cut Points

Vehicle Type	Model Year	Sierra + current cut points			DEQ + current cut points		
		Number	Fail Rate	Avg Test Time	Number	Fail Rate	Avg Test Time
LDT2	1981	17	29%	134.1	17	24%	85.9
	1982	22	45%	127.9	22	32%	80.1
	1983	34	21%	117.7	34	21%	103.8
	1984	51	37%	141.1	51	20%	102.4
	1985	79	24%	91.6	79	25%	107.9
	1986	67	36%	103.4	67	36%	127.9
	1987	81	9%	82.3	81	9%	107.4
	1988	130	12%	91.4	130	9%	92.8
	1989	150	12%	74.9	150	9%	75.6
	1990	139	7%	88.2	139	6%	97.8
	1991	132	5%	83.8	132	5%	92.8
	1992	184	5%	88.9	184	4%	64.6
	1993	226	4%	67.2	226	2%	103.3
	1994	377	3%	83.5	377	2%	83.2
	1995	745	6%	78.7	745	2%	86.5
	1996	41	0%	26.9	41	2%	30.6
	1997	35	0%	16.0	35	0%	21.0
	1998	23	0%	16.0	23	0%	16.5
	1999	21	0%	16.0	21	0%	16.6
	2000	7	0%	16.0	7	0%	17.7
LDT1	1981	63	38%	112.1	63	32%	125.0
	1982	52	33%	98.8	52	27%	121.8
	1983	95	35%	105.2	95	29%	110.5
	1984	165	24%	99.5	165	23%	116.1
	1985	213	22%	84.0	213	21%	116.6
	1986	349	24%	99.5	349	25%	120.8
	1987	343	19%	94.6	343	15%	116.2
	1988	348	14%	88.2	348	11%	120.8
	1989	399	11%	93.6	399	8%	123.5
	1990	436	17%	100.1	436	15%	115.8
	1991	657	11%	91.4	657	9%	98.1
	1992	570	9%	82.0	570	9%	106.6
	1993	795	9%	78.4	795	7%	97.9
	1994	801	9%	81.2	801	5%	101.1
	1995	2,033	7%	69.1	2,033	3%	41.6
	1996	71	3%	24.5	71	3%	27.9
	1997	58	0%	18.9	58	0%	19.7
	1998	51	0%	20.6	51	0%	25.9
	1999	26	4%	20.5	26	4%	19.2
	2000	12	0%	16.0	12	0%	16.0
Car	1981	94	29%	120.6	94	29%	127.7
	1982	115	23%	113.7	115	24%	131.6
	1983	210	29%	106.7	210	30%	125.0
	1984	325	27%	115.1	325	25%	125.5
	1985	456	20%	96.5	456	20%	131.5
	1986	580	22%	116.7	580	19%	130.9
	1987	750	21%	119.1	750	17%	121.1
	1988	815	13%	110.0	815	12%	137.4
	1989	821	13%	115.5	821	11%	148.7
	1990	1,057	11%	119.8	1,057	9%	129.2
	1991	1,100	9%	119.4	1,100	7%	130.8
	1992	1,418	6%	109.1	1,418	4%	128.3
	1993	1,099	5%	111.4	1,099	4%	138.5
	1994	1,588	7%	105.6	1,588	3%	128.1
	1995	4,085	3%	80.5	4,085	1%	54.9
	1996	110	0%	44.5	110	0%	70.2
	1997	87	1%	27.8	87	1%	47.1
	1998	70	0%	25.2	70	0%	32.0
	1999	61	0%	23.1	61	0%	27.6
	2000	15	0%	16.0	15	0%	16.0
Total		24,954	10.0%	93.5	24,954	7.6%	100.2

Table A-3. Number of Vehicles, Fail Rate, and Average Test Time by Type and Model Year. Sierra and DEQ Methods using EEA Cut Points

Vehicle Type	Model Year	Sierra + EEA cut points			DEQ + EEA cut points		
		Number	Fail Rate	Avg Test Time	Number	Fail Rate	Avg Test Time
LDT2	1981	18	28%	115.3	18	22%	100.4
	1982	21	33%	128.3	21	24%	72.0
	1983	37	27%	116.3	37	19%	105.4
	1984	46	37%	147.5	46	24%	117.3
	1985	75	31%	125.9	75	31%	131.2
	1986	59	39%	120.7	59	41%	136.0
	1987	74	18%	121.2	74	15%	144.3
	1988	132	17%	97.2	132	13%	100.4
	1989	148	14%	89.3	148	9%	88.0
	1990	139	9%	88.6	139	6%	102.9
	1991	137	6%	81.5	137	4%	96.2
	1992	182	11%	101.6	182	5%	67.9
	1993	216	6%	106.7	216	4%	125.9
	1994	286	10%	94.5	286	2%	90.5
	1995	576	11%	88.6	576	3%	94.9
	1996	33	0%	29.6	33	9%	41.3
	1997	23	0%	16.0	23	4%	28.0
	1998	19	0%	16.0	19	0%	21.1
	1999	18	0%	16.0	18	0%	16.0
	2000	7	0%	16.0	7	0%	17.7
LDT1	1981	59	44%	147.9	59	39%	143.7
	1982	50	38%	121.5	50	38%	137.1
	1983	89	47%	140.4	89	40%	143.2
	1984	151	32%	135.0	151	28%	145.0
	1985	196	29%	119.2	196	28%	139.0
	1986	342	36%	116.9	342	35%	149.1
	1987	328	32%	117.4	328	23%	139.6
	1988	299	30%	115.7	299	25%	157.8
	1989	325	33%	112.9	325	24%	154.2
	1990	461	25%	105.8	461	15%	123.7
	1991	656	20%	95.1	656	12%	111.0
	1992	591	14%	90.3	591	10%	114.0
	1993	688	17%	96.3	688	10%	117.2
	1994	389	28%	103.9	389	21%	117.5
	1995	1,790	26%	86.9	1,790	7%	50.0
	1996	52	8%	28.4	52	6%	32.0
	1997	52	0%	23.1	52	0%	22.7
	1998	43	0%	26.1	43	2%	25.5
	1999	23	4%	21.8	23	4%	20.1
	2000	12	0%	16.5	12	0%	16.5
Car	1981	88	33%	137.3	88	32%	136.9
	1982	108	34%	160.2	108	35%	162.5
	1983	200	30%	119.0	200	30%	137.5
	1984	319	36%	141.7	319	32%	156.3
	1985	452	27%	134.9	452	26%	162.3
	1986	585	15%	86.2	585	15%	119.5
	1987	752	17%	101.0	752	16%	116.2
	1988	802	13%	117.2	802	12%	145.7
	1989	771	18%	137.1	771	14%	170.0
	1990	1,057	13%	108.2	1,057	10%	127.6
	1991	1,153	16%	122.9	1,153	9%	134.6
	1992	1,035	17%	118.0	1,035	12%	146.3
	1993	634	26%	128.6	634	21%	169.4
	1994	1,165	17%	115.2	1,165	10%	140.0
	1995	3,439	10%	99.6	3,439	3%	61.3
	1996	85	6%	56.8	85	2%	70.1
	1997	72	3%	33.7	72	1%	41.9
	1998	61	2%	24.9	61	2%	27.5
	1999	54	0%	18.9	54	0%	22.9
	2000	15	0%	16.0	15	0%	16.0
Total		21,689	18.4%	105.9	21,689	12.0%	111.9

Table A-4. Sierra Method Fail Rate, Average Test Time, and Excess Emissions Identified by Vehicle Type and Method, using Current Cut Points and Measured Miles Traveled. Based on vehicles given three full IM147 traces.

Vehicle Type	Model Year	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Avg Test Time	% Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
LDT2	1981	4	25%	0%	25%	100%	0%	NA	184.0	NA	0%	NA
	1982	2	50%	50%	0%	NA	0%	NA	104.0	NA	100%	NA
	1983	6	0%	0%	0%	NA	0%	NA	196.3	NA	NA	NA
	1984	6	33%	33%	17%	50%	17%	25%	168.7	NA	7%	NA
	1985	10	30%	20%	20%	67%	10%	14%	185.8	NA	36%	NA
	1986	4	0%	0%	0%	NA	0%	NA	108.5	NA	NA	NA
	1987	13	0%	0%	0%	NA	0%	NA	96.9	NA	NA	NA
	1988	23	0%	0%	0%	NA	0%	NA	136.0	NA	NA	NA
	1989	20	5%	5%	5%	100%	5%	5%	117.3	NA	NA	0%
	1990	14	0%	0%	0%	NA	0%	NA	151.4	NA	NA	NA
	1991	13	0%	0%	0%	NA	0%	NA	138.5	NA	NA	NA
	1992	24	4%	4%	0%	NA	0%	NA	170.6	NA	100%	NA
	1993	16	0%	6%	0%	NA	6%	6%	130.8	NA	NA	NA
	1994	6	17%	0%	17%	100%	0%	NA	294.3	NA	NA	0%
	1995	9	11%	33%	11%	100%	33%	38%	238.4	NA	NA	0%
LDT1	1981	9	0%	0%	0%	NA	0%	NA	116.2	NA	NA	NA
	1982	8	0%	13%	0%	NA	13%	13%	112.5	NA	NA	NA
	1983	16	6%	13%	0%	NA	6%	7%	128.0	NA	NA	100%
	1984	22	9%	0%	9%	100%	0%	NA	144.5	NA	0%	NA
	1985	23	0%	0%	0%	NA	0%	NA	122.9	NA	NA	NA
	1986	26	27%	8%	19%	71%	0%	NA	175.4	NA	NA	17%
	1987	29	38%	17%	21%	55%	0%	NA	163.5	NA	0%	50%
	1988	30	27%	37%	7%	25%	17%	23%	190.4	NA	NA	70%
	1989	29	24%	28%	7%	29%	10%	14%	218.8	NA	NA	83%
	1990	52	4%	2%	2%	50%	0%	NA	174.0	NA	100%	50%
	1991	45	4%	4%	4%	100%	4%	5%	154.0	NA	0%	NA
	1992	53	4%	6%	2%	50%	4%	4%	147.2	NA	53%	NA
	1993	57	2%	5%	0%	NA	4%	4%	138.6	NA	NA	100%
	1994	14	14%	36%	7%	50%	29%	33%	227.0	100%	0%	100%
	1995	20	10%	40%	0%	NA	30%	33%	185.3	NA	NA	100%
Car	1981	21	5%	0%	5%	100%	0%	NA	139.8	NA	0%	NA
	1982	31	0%	3%	0%	NA	3%	3%	166.3	NA	NA	NA
	1983	58	2%	2%	2%	100%	2%	2%	133.8	NA	0%	NA
	1984	98	3%	1%	2%	67%	0%	NA	149.9	NA	0%	100%
	1985	108	3%	3%	2%	67%	2%	2%	133.4	NA	0%	57%
	1986	64	11%	9%	5%	43%	3%	4%	219.4	NA	0%	52%
	1987	92	12%	7%	8%	64%	2%	2%	219.7	NA	74%	93%
	1988	80	14%	10%	8%	55%	4%	4%	226.0	NA	13%	98%
	1989	107	14%	10%	7%	53%	4%	4%	236.0	NA	50%	73%
	1990	91	10%	15%	3%	33%	9%	10%	250.7	NA	57%	100%
	1991	111	18%	19%	6%	35%	7%	9%	252.4	100%	69%	69%
	1992	90	13%	17%	7%	50%	10%	12%	256.7	NA	19%	43%
	1993	74	14%	15%	4%	30%	5%	6%	236.5	NA	63%	100%
	1994	75	43%	49%	9%	22%	16%	28%	265.7	0%	74%	89%
	1995	71	48%	37%	15%	32%	4%	8%	259.1	100%	86%	71%
	1996	1	0%	0%	0%	NA	0%	NA	298.0	NA	NA	NA
Total		1,775	12.8%	12.6%	5.4%	42.3%	5.2%	5.9%	196.5	86%	45%	67%

Table A-5. DEQ Method Fail Rate, Average Test Time, and Excess Emissions Identified by Vehicle Type and Method, using Current Cut Points and Measured Miles Traveled. Based on vehicles given three full IM147 traces.

Vehicle Type	Model Year	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Avg Test Time	% Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
LDT2	1981	4	25%	0%	25%	100%	0%	NA	120.0	NA	0%	NA
	1982	2	50%	0%	50%	100%	0%	NA	108.0	NA	0%	NA
	1983	6	0%	0%	0%	NA	0%	NA	144.3	NA	NA	NA
	1984	6	33%	0%	33%	100%	0%	NA	107.0	NA	0%	NA
	1985	10	30%	30%	10%	33%	10%	14%	230.8	NA	54%	NA
	1986	4	0%	0%	0%	NA	0%	NA	355.5	NA	NA	NA
	1987	13	0%	0%	0%	NA	0%	NA	138.8	NA	NA	NA
	1988	23	0%	0%	0%	NA	0%	NA	144.7	NA	NA	NA
	1989	20	5%	0%	5%	100%	0%	NA	119.8	NA	NA	0%
	1990	14	0%	0%	0%	NA	0%	NA	160.7	NA	NA	NA
	1991	13	0%	0%	0%	NA	0%	NA	121.5	NA	NA	NA
	1992	24	4%	0%	4%	100%	0%	NA	104.3	NA	0%	NA
	1993	16	0%	0%	0%	NA	0%	NA	157.4	NA	NA	NA
	1994	6	17%	0%	17%	100%	0%	NA	231.3	NA	NA	0%
	1995	9	11%	0%	11%	100%	0%	NA	225.8	NA	NA	0%
LDT1	1981	9	0%	0%	0%	NA	0%	NA	164.7	NA	NA	NA
	1982	8	0%	0%	0%	NA	0%	NA	158.0	NA	NA	NA
	1983	16	6%	0%	6%	100%	0%	NA	163.9	NA	NA	0%
	1984	22	9%	9%	0%	NA	0%	NA	193.6	NA	100%	NA
	1985	23	0%	0%	0%	NA	0%	NA	209.4	NA	NA	NA
	1986	26	27%	8%	19%	71%	0%	NA	260.4	NA	NA	51%
	1987	29	38%	14%	24%	64%	0%	NA	188.6	NA	0%	50%
	1988	30	27%	17%	10%	38%	0%	NA	262.1	NA	NA	66%
	1989	29	24%	3%	21%	86%	0%	NA	282.6	NA	NA	50%
	1990	52	4%	2%	2%	50%	0%	NA	197.3	NA	100%	50%
	1991	45	4%	0%	4%	100%	0%	NA	174.3	NA	0%	NA
	1992	53	4%	2%	2%	50%	0%	NA	187.9	NA	47%	NA
	1993	57	2%	0%	2%	100%	0%	NA	187.3	NA	NA	0%
	1994	14	14%	7%	7%	50%	0%	NA	267.9	0%	100%	0%
	1995	20	10%	0%	10%	100%	0%	NA	102.5	NA	NA	0%
Car	1981	21	5%	5%	5%	100%	5%	5%	153.1	NA	0%	NA
	1982	31	0%	6%	0%	NA	6%	6%	209.4	NA	NA	NA
	1983	58	2%	3%	0%	NA	2%	2%	182.5	NA	100%	NA
	1984	98	3%	0%	3%	100%	0%	NA	179.5	NA	0%	0%
	1985	108	3%	3%	1%	33%	1%	1%	191.8	NA	100%	57%
	1986	64	11%	2%	9%	86%	0%	NA	230.4	NA	100%	0%
	1987	92	12%	3%	10%	82%	1%	1%	215.6	NA	7%	4%
	1988	80	14%	6%	9%	64%	1%	1%	272.3	NA	98%	0%
	1989	107	14%	8%	6%	40%	0%	NA	282.3	NA	84%	46%
	1990	91	10%	7%	4%	44%	1%	1%	259.8	NA	57%	0%
	1991	111	18%	8%	10%	55%	0%	NA	262.2	100%	80%	0%
	1992	90	13%	4%	9%	67%	0%	NA	275.0	NA	72%	0%
	1993	74	14%	12%	3%	20%	1%	2%	287.1	NA	93%	0%
	1994	75	43%	32%	11%	25%	0%	NA	329.6	0%	67%	86%
	1995	71	48%	4%	44%	91%	0%	NA	135.1	100%	0%	11%
	1996	1	0%	0%	0%	NA	0%	NA	372.0	NA	NA	NA
Total		1,775	12.8%	5.7%	7.7%	59.9%	0.6%	0.6%	220.6	81%	58%	39%

Table A-6. Sierra Method Fail Rate, Average Test Time, and Excess Emissions Identified by Vehicle Type and Method, using Current Cut Points and 1.4 Miles Traveled. Based on vehicles given three full IM147 traces.

Vehicle Type	Model Year	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Avg Test Time	% Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
LDT2	1981	4	0%	0%	0%	NA	0%	NA	184.0	NA	NA	NA
	1982	2	50%	50%	0%	NA	0%	NA	104.0	NA	100%	NA
	1983	6	0%	0%	0%	NA	0%	NA	196.3	NA	NA	NA
	1984	6	17%	33%	17%	100%	33%	40%	168.7	NA	0%	NA
	1985	10	20%	20%	10%	50%	10%	13%	185.8	NA	45%	NA
	1986	4	0%	0%	0%	NA	0%	NA	108.5	NA	NA	NA
	1987	13	0%	0%	0%	NA	0%	NA	96.9	NA	NA	NA
	1988	23	0%	0%	0%	NA	0%	NA	136.0	NA	NA	NA
	1989	20	5%	5%	5%	100%	5%	5%	117.3	NA	NA	0%
	1990	14	0%	0%	0%	NA	0%	NA	151.4	NA	NA	NA
	1991	13	0%	0%	0%	NA	0%	NA	138.5	NA	NA	NA
	1992	24	4%	4%	0%	NA	0%	NA	170.6	NA	100%	NA
	1993	16	0%	6%	0%	NA	6%	6%	130.8	NA	NA	NA
	1994	6	17%	0%	17%	100%	0%	NA	294.3	NA	NA	0%
	1995	9	0%	33%	0%	NA	33%	33%	238.4	NA	NA	NA
LDT1	1981	9	0%	0%	0%	NA	0%	NA	116.2	NA	NA	NA
	1982	8	13%	13%	0%	NA	0%	NA	112.5	NA	NA	100%
	1983	16	0%	13%	0%	NA	13%	13%	128.0	NA	NA	NA
	1984	22	9%	0%	9%	100%	0%	NA	144.5	NA	0%	NA
	1985	23	0%	0%	0%	NA	0%	NA	122.9	NA	NA	NA
	1986	26	19%	8%	12%	60%	0%	NA	175.4	NA	NA	27%
	1987	29	17%	17%	3%	20%	3%	4%	163.5	NA	NA	89%
	1988	30	23%	37%	3%	14%	17%	22%	190.4	NA	NA	84%
	1989	29	21%	28%	10%	50%	17%	22%	218.8	NA	NA	69%
	1990	52	2%	2%	0%	NA	0%	NA	174.0	NA	NA	100%
	1991	45	0%	4%	0%	NA	4%	4%	154.0	NA	NA	NA
	1992	53	4%	6%	2%	50%	4%	4%	147.2	NA	53%	NA
	1993	57	0%	5%	0%	NA	5%	5%	138.6	NA	NA	NA
	1994	14	14%	36%	7%	50%	29%	33%	227.0	NA	0%	100%
	1995	20	10%	40%	0%	NA	30%	33%	185.3	NA	NA	100%
Car	1981	21	5%	0%	5%	100%	0%	NA	139.8	NA	0%	NA
	1982	31	0%	3%	0%	NA	3%	3%	166.3	NA	NA	NA
	1983	58	3%	2%	3%	100%	2%	2%	133.8	NA	0%	NA
	1984	98	2%	1%	1%	50%	0%	NA	149.9	NA	0%	100%
	1985	108	2%	3%	1%	50%	2%	2%	133.4	NA	0%	100%
	1986	64	9%	9%	3%	33%	3%	3%	219.4	NA	0%	83%
	1987	92	8%	7%	3%	43%	2%	2%	219.7	NA	86%	81%
	1988	80	11%	10%	6%	56%	5%	6%	226.0	NA	18%	98%
	1989	107	8%	10%	4%	44%	6%	6%	236.0	NA	29%	100%
	1990	91	7%	15%	1%	17%	10%	11%	250.7	NA	80%	NA
	1991	111	14%	19%	3%	19%	7%	8%	252.4	NA	78%	76%
	1992	90	9%	17%	3%	38%	11%	12%	256.7	NA	23%	73%
	1993	74	11%	15%	3%	25%	7%	8%	236.5	NA	64%	100%
	1994	75	33%	49%	3%	8%	19%	28%	265.7	NA	100%	93%
	1995	71	38%	37%	7%	19%	6%	9%	259.1	100%	82%	84%
	1996	1	0%	0%	0%	NA	0%	NA	298.0	NA	NA	NA
Total		1,775	9.5%	12.6%	2.9%	30.4%	6.0%	6.6%	196.5	100%	57%	80%

Table A-7. DEQ Method Fail Rate, Average Test Time, and Excess Emissions Identified by Vehicle Type and Method, using Current Cut Points and 1.4 Miles Traveled. Based on vehicles given three full IM147 traces.

Vehicle Type	Model Year	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Avg Test Time	% Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
LDT2	1981	4	0%	0%	0%	NA	0%	NA	120.0	NA	NA	NA
	1982	2	50%	0%	50%	100%	0%	NA	108.0	NA	0%	NA
	1983	6	0%	0%	0%	NA	0%	NA	144.3	NA	NA	NA
	1984	6	17%	0%	17%	100%	0%	NA	107.0	NA	0%	NA
	1985	10	20%	30%	10%	50%	20%	25%	230.8	NA	45%	NA
	1986	4	0%	0%	0%	NA	0%	NA	355.5	NA	NA	NA
	1987	13	0%	0%	0%	NA	0%	NA	138.8	NA	NA	NA
	1988	23	0%	0%	0%	NA	0%	NA	144.7	NA	NA	NA
	1989	20	5%	0%	5%	100%	0%	NA	119.8	NA	NA	0%
	1990	14	0%	0%	0%	NA	0%	NA	160.7	NA	NA	NA
	1991	13	0%	0%	0%	NA	0%	NA	121.5	NA	NA	NA
	1992	24	4%	0%	4%	100%	0%	NA	104.3	NA	0%	NA
	1993	16	0%	0%	0%	NA	0%	NA	157.4	NA	NA	NA
	1994	6	17%	0%	17%	100%	0%	NA	231.3	NA	NA	0%
	1995	9	0%	0%	0%	NA	0%	NA	225.8	NA	NA	NA
LDT1	1981	9	0%	0%	0%	NA	0%	NA	164.7	NA	NA	NA
	1982	8	13%	0%	13%	100%	0%	NA	158.0	NA	NA	0%
	1983	16	0%	0%	0%	NA	0%	NA	163.9	NA	NA	NA
	1984	22	9%	9%	0%	NA	0%	NA	193.6	NA	100%	NA
	1985	23	0%	0%	0%	NA	0%	NA	209.4	NA	NA	NA
	1986	26	19%	8%	12%	60%	0%	NA	260.4	NA	NA	44%
	1987	29	17%	14%	3%	20%	0%	NA	188.6	NA	NA	89%
	1988	30	23%	17%	7%	29%	0%	NA	262.1	NA	NA	79%
	1989	29	21%	3%	17%	83%	0%	NA	282.6	NA	NA	48%
	1990	52	2%	2%	0%	NA	0%	NA	197.3	NA	NA	100%
	1991	45	0%	0%	0%	NA	0%	NA	174.3	NA	NA	NA
	1992	53	4%	2%	2%	50%	0%	NA	187.9	NA	47%	NA
	1993	57	0%	0%	0%	NA	0%	NA	187.3	NA	NA	NA
	1994	14	14%	7%	7%	50%	0%	NA	267.9	NA	100%	0%
	1995	20	10%	0%	10%	100%	0%	NA	102.5	NA	NA	0%
Car	1981	21	5%	5%	5%	100%	5%	5%	153.1	NA	0%	NA
	1982	31	0%	6%	0%	NA	6%	6%	209.4	NA	NA	NA
	1983	58	3%	3%	0%	NA	0%	NA	182.5	NA	100%	NA
	1984	98	2%	0%	2%	100%	0%	NA	179.5	NA	0%	0%
	1985	108	2%	3%	0%	NA	1%	1%	191.8	NA	100%	100%
	1986	64	9%	2%	8%	83%	0%	NA	230.4	NA	100%	0%
	1987	92	8%	3%	5%	71%	1%	1%	215.6	NA	14%	5%
	1988	80	11%	6%	6%	56%	1%	1%	272.3	NA	98%	0%
	1989	107	8%	8%	1%	11%	1%	1%	282.3	NA	100%	87%
	1990	91	7%	7%	1%	17%	1%	1%	259.8	NA	80%	NA
	1991	111	14%	8%	6%	44%	0%	NA	262.2	NA	95%	0%
	1992	90	9%	4%	4%	50%	0%	NA	275.0	NA	75%	0%
	1993	74	11%	12%	1%	13%	3%	3%	287.1	NA	100%	0%
	1994	75	33%	32%	3%	8%	1%	2%	329.6	NA	100%	97%
	1995	71	38%	4%	34%	89%	0%	NA	135.1	100%	0%	15%
	1996	1	0%	0%	0%	NA	0%	NA	372.0	NA	NA	NA
Total		1,775	9.5%	5.7%	4.5%	47.6%	0.7%	0.8%	220.6	100%	67%	58%

Table A-8. Sierra Method Fail Rate, Average Test Time, and Excess Emissions Identified by Vehicle Type and Method, using EEA Cut Points and Measured Miles Traveled. Based on vehicles given three full IM147 traces.

Vehicle Type	Model Year	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Avg Test Time	% Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
LDT2	1981	4	0%	0%	0%	NA	0%	NA	186.0	NA	NA	NA
	1982	2	0%	0%	0%	NA	0%	NA	216.0	NA	NA	NA
	1983	6	0%	0%	0%	NA	0%	NA	177.3	NA	NA	NA
	1984	6	33%	50%	17%	50%	33%	50%	273.0	NA	0%	100%
	1985	10	70%	50%	20%	29%	0%	NA	291.2	NA	62%	100%
	1986	4	75%	25%	50%	67%	0%	NA	196.5	NA	39%	NA
	1987	13	31%	46%	8%	25%	23%	33%	186.6	0%	100%	100%
	1988	23	17%	13%	9%	50%	4%	5%	180.7	0%	NA	87%
	1989	20	25%	25%	10%	40%	10%	13%	167.6	80%	NA	88%
	1990	14	14%	7%	14%	100%	7%	8%	145.9	0%	NA	0%
	1991	13	8%	0%	8%	100%	0%	NA	153.4	NA	NA	0%
	1992	24	25%	25%	8%	33%	8%	11%	223.4	100%	NA	67%
	1993	16	25%	38%	0%	NA	13%	17%	278.0	100%	NA	100%
	1994	6	33%	17%	17%	50%	0%	NA	277.7	100%	100%	0%
	1995	9	33%	56%	11%	33%	33%	50%	238.7	100%	NA	0%
LDT1	1981	9	11%	11%	0%	NA	0%	NA	232.0	NA	100%	NA
	1982	9	56%	44%	22%	40%	11%	25%	210.9	NA	65%	63%
	1983	16	63%	50%	19%	30%	6%	17%	213.8	100%	64%	90%
	1984	22	45%	41%	27%	60%	23%	42%	250.3	NA	81%	37%
	1985	23	52%	26%	30%	58%	4%	9%	261.3	100%	44%	21%
	1986	26	58%	54%	12%	20%	8%	18%	201.2	NA	NA	85%
	1987	29	86%	83%	10%	12%	7%	50%	245.5	100%	43%	93%
	1988	30	87%	77%	13%	15%	3%	25%	195.4	100%	NA	87%
	1989	29	97%	93%	3%	4%	0%	NA	177.0	100%	NA	99%
	1990	52	52%	54%	12%	22%	13%	28%	206.2	0%	NA	88%
	1991	45	49%	47%	9%	18%	7%	13%	219.6	NA	NA	86%
	1992	53	36%	38%	8%	21%	9%	15%	187.6	NA	NA	80%
	1993	56	32%	43%	7%	22%	18%	26%	217.7	100%	NA	79%
	1994	14	93%	93%	7%	8%	7%	100%	207.9	100%	98%	100%
	1995	20	100%	95%	5%	5%	0%	NA	194.0	100%	82%	100%
Car	1981	21	14%	10%	5%	33%	0%	NA	181.1	NA	100%	0%
	1982	31	29%	29%	3%	11%	3%	5%	240.3	100%	85%	NA
	1983	58	9%	5%	5%	60%	2%	2%	158.0	100%	0%	77%
	1984	98	30%	27%	10%	34%	7%	10%	209.8	100%	2%	92%
	1985	108	23%	21%	6%	28%	5%	6%	217.0	100%	47%	83%
	1986	64	0%	0%	0%	NA	0%	NA	116.1	NA	NA	NA
	1987	92	4%	4%	3%	75%	3%	3%	164.7	50%	0%	0%
	1988	80	20%	18%	8%	38%	5%	6%	256.2	100%	0%	74%
	1989	112	27%	34%	4%	13%	11%	15%	274.0	100%	100%	83%
	1990	91	26%	30%	9%	33%	12%	16%	233.1	NA	NA	76%
	1991	111	61%	53%	12%	19%	4%	9%	259.0	NA	NA	86%
	1992	90	81%	80%	2%	3%	1%	6%	235.0	NA	NA	99%
	1993	73	78%	82%	0%	NA	4%	19%	234.3	NA	NA	100%
	1994	74	81%	80%	4%	5%	3%	14%	204.4	100%	0%	100%
	1995	71	97%	96%	3%	3%	1%	50%	239.6	100%	89%	100%
	1996	1	0%	0%	0%	NA	0%	NA	324.0	NA	NA	NA
Total		1,778	43.1%	42.0%	7.3%	17%	6.2%	10.9%	217.0	89%	67%	93%

Table A-9. DEQ Method Fail Rate, Average Test Time, and Excess Emissions Identified by Vehicle Type and Method, using EEA Cut Points and Measured Miles Traveled. Based on vehicles given three full IM147 traces.

Vehicle Type	Model Year	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Avg Test Time	% Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
LDT2	1981	4	0%	0%	0%	NA	0%	NA	116.0	NA	NA	NA
	1982	2	0%	0%	0%	NA	0%	NA	98.0	NA	NA	NA
	1983	6	0%	0%	0%	NA	0%	NA	151.3	NA	NA	NA
	1984	6	33%	17%	33%	100%	17%	25%	183.3	NA	0%	0%
	1985	10	70%	50%	20%	29%	0%	NA	284.0	NA	62%	100%
	1986	4	75%	75%	0%	NA	0%	NA	359.0	NA	100%	NA
	1987	13	31%	31%	0%	NA	0%	NA	248.3	100%	100%	100%
	1988	23	17%	13%	4%	25%	0%	NA	168.5	100%	NA	87%
	1989	20	25%	5%	20%	80%	0%	NA	164.4	30%	NA	10%
	1990	14	14%	0%	14%	100%	0%	NA	191.7	0%	NA	0%
	1991	13	8%	0%	8%	100%	0%	NA	153.1	NA	NA	0%
	1992	24	25%	0%	25%	100%	0%	NA	107.2	0%	NA	0%
	1993	16	25%	13%	13%	50%	0%	NA	254.4	100%	NA	47%
	1994	6	33%	17%	17%	50%	0%	NA	237.7	100%	100%	0%
	1995	9	33%	11%	22%	67%	0%	NA	257.3	85%	NA	0%
LDT1	1981	9	11%	11%	0%	NA	0%	NA	244.4	NA	100%	NA
	1982	9	56%	44%	22%	40%	11%	25%	250.0	NA	65%	63%
	1983	16	63%	31%	31%	50%	0%	NA	258.8	100%	64%	37%
	1984	22	45%	23%	27%	60%	5%	8%	277.2	NA	81%	37%
	1985	23	52%	22%	30%	58%	0%	NA	305.0	100%	44%	21%
	1986	26	58%	46%	15%	27%	4%	9%	325.8	NA	NA	86%
	1987	29	86%	45%	41%	48%	0%	NA	280.3	90%	43%	62%
	1988	30	87%	70%	17%	19%	0%	NA	348.5	74%	NA	92%
	1989	29	97%	83%	14%	14%	0%	NA	372.9	100%	NA	92%
	1990	52	52%	19%	33%	63%	0%	NA	242.0	0%	NA	53%
	1991	45	49%	24%	24%	50%	0%	NA	252.8	NA	NA	53%
	1992	53	36%	21%	15%	42%	0%	NA	235.7	NA	NA	66%
	1993	56	32%	18%	14%	44%	0%	NA	280.1	100%	NA	72%
	1994	14	93%	86%	7%	8%	0%	NA	382.6	100%	98%	100%
	1995	20	100%	15%	85%	85%	0%	NA	159.3	0%	0%	25%
Car	1981	21	14%	10%	10%	67%	5%	6%	185.9	NA	35%	0%
	1982	31	29%	35%	0%	NA	6%	9%	266.2	100%	100%	NA
	1983	58	9%	7%	2%	20%	0%	NA	216.2	100%	100%	77%
	1984	98	30%	15%	14%	48%	0%	NA	249.7	100%	24%	71%
	1985	108	23%	19%	5%	20%	0%	NA	260.4	100%	93%	85%
	1986	64	0%	0%	0%	NA	0%	NA	167.5	NA	NA	NA
	1987	92	4%	2%	2%	50%	0%	NA	194.3	100%	0%	0%
	1988	80	20%	13%	11%	56%	4%	5%	301.5	100%	0%	66%
	1989	112	27%	18%	10%	37%	1%	1%	336.4	100%	100%	82%
	1990	91	26%	12%	14%	54%	0%	NA	268.0	NA	NA	59%
	1991	111	61%	27%	34%	56%	0%	NA	291.4	NA	NA	64%
	1992	90	81%	71%	10%	12%	0%	NA	355.1	NA	NA	96%
	1993	73	78%	75%	3%	4%	0%	NA	360.7	NA	NA	98%
	1994	74	81%	77%	4%	5%	0%	NA	365.7	100%	0%	100%
	1995	71	97%	18%	79%	81%	0%	NA	190.4	100%	3%	24%
	1996	1	0%	0%	0%	NA	0%	NA	372.0	NA	NA	NA
Total		1,778	43.1%	27.1%	16.6%	39%	0.6%	1.1%	267.9	82%	66%	74%

Table A-10. Sierra Method Fail Rate, Average Test Time, and Excess Emissions Identified by Vehicle Type and Method, using EEA Cut Points and 1.4 Miles Traveled. Based on vehicles given three full IM147 traces.

Vehicle Type	Model Year	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Avg Test Time	% Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
LDT2	1981	4	0%	0%	0%	NA	0%	NA	186.0	NA	NA	NA
	1982	2	0%	0%	0%	NA	0%	NA	216.0	NA	NA	NA
	1983	6	0%	0%	0%	NA	0%	NA	177.3	NA	NA	NA
	1984	6	17%	50%	0%	NA	33%	40%	273.0	NA	NA	100%
	1985	10	60%	50%	10%	17%	0%	NA	291.2	NA	68%	100%
	1986	4	75%	25%	50%	67%	0%	NA	196.5	NA	55%	NA
	1987	13	31%	46%	8%	25%	23%	33%	186.6	0%	100%	100%
	1988	23	17%	13%	9%	50%	4%	5%	180.7	0%	NA	87%
	1989	20	15%	25%	0%	NA	10%	12%	167.6	100%	NA	100%
	1990	14	0%	7%	0%	NA	7%	7%	145.9	NA	NA	NA
	1991	13	0%	0%	0%	NA	0%	NA	153.4	NA	NA	NA
	1992	24	25%	25%	8%	33%	8%	11%	223.4	100%	NA	68%
	1993	16	25%	38%	0%	NA	13%	17%	278.0	100%	NA	100%
	1994	6	33%	17%	17%	50%	0%	NA	277.7	100%	100%	0%
	1995	9	11%	56%	0%	NA	44%	50%	238.7	100%	NA	NA
LDT1	1981	9	11%	11%	0%	NA	0%	NA	232.0	NA	100%	NA
	1982	9	44%	44%	11%	25%	11%	20%	210.9	NA	54%	100%
	1983	16	50%	50%	6%	13%	6%	13%	213.8	100%	78%	100%
	1984	22	18%	41%	0%	NA	23%	28%	250.3	NA	100%	100%
	1985	23	39%	26%	17%	44%	4%	7%	261.3	100%	53%	38%
	1986	26	54%	54%	8%	14%	8%	17%	201.2	NA	NA	84%
	1987	29	76%	83%	3%	5%	10%	43%	245.5	100%	100%	97%
	1988	30	83%	77%	10%	12%	3%	20%	195.4	100%	NA	89%
	1989	29	93%	93%	0%	NA	0%	NA	177.0	100%	NA	100%
	1990	52	48%	54%	8%	16%	13%	26%	206.2	NA	NA	89%
	1991	45	47%	47%	7%	14%	7%	13%	219.6	NA	NA	89%
	1992	53	32%	38%	4%	12%	9%	14%	187.6	NA	NA	90%
	1993	56	30%	43%	5%	18%	18%	26%	217.7	100%	NA	79%
	1994	14	93%	93%	7%	8%	7%	100%	207.9	100%	98%	100%
	1995	20	80%	95%	0%	NA	15%	75%	194.0	100%	100%	100%
Car	1981	21	14%	10%	5%	33%	0%	NA	181.1	NA	100%	0%
	1982	31	19%	29%	0%	NA	10%	12%	240.3	100%	100%	NA
	1983	58	9%	5%	5%	60%	2%	2%	158.0	100%	0%	77%
	1984	98	29%	27%	9%	32%	7%	10%	209.8	100%	11%	91%
	1985	108	22%	21%	6%	25%	5%	6%	217.0	100%	49%	81%
	1986	64	0%	0%	0%	NA	0%	NA	116.1	NA	NA	NA
	1987	92	2%	4%	1%	50%	3%	3%	164.7	52%	NA	NA
	1988	80	16%	18%	5%	31%	6%	7%	256.2	100%	NA	65%
	1989	112	25%	34%	3%	11%	12%	15%	274.0	100%	NA	84%
	1990	91	23%	30%	5%	24%	12%	16%	233.1	NA	NA	81%
	1991	111	46%	53%	5%	10%	12%	22%	259.0	NA	NA	93%
	1992	90	76%	80%	1%	1%	6%	23%	235.0	NA	NA	100%
	1993	73	78%	82%	0%	NA	4%	19%	234.3	NA	NA	100%
	1994	74	77%	80%	0%	NA	3%	12%	204.4	100%	NA	100%
	1995	71	97%	96%	3%	3%	1%	50%	239.6	100%	86%	100%
	1996	1	0%	0%	0%	NA	0%	NA	324.0	NA	NA	NA
Total		1,778	38.8%	42.0%	4.2%	11%	7.4%	12.1%	217.0	91%	76%	95%

Table A-11. DEQ Method Fail Rate, Average Test Time, and Excess Emissions Identified by Vehicle Type and Method, using EEA Cut Points and 1.4 Miles Traveled. Based on vehicles given three full IM147 traces.

Vehicle Type	Model Year	Number	Actual Fail Rate	Method Fail Rate	False Pass Rate		False Fail Rate		Avg Test Time	% Excess Emissions Identified		
					of All	of All Fails	of All	of All Passes		HC	CO	NOx
LDT2	1981	4	0%	0%	0%	NA	0%	NA	116.0	NA	NA	NA
	1982	2	0%	0%	0%	NA	0%	NA	98.0	NA	NA	NA
	1983	6	0%	0%	0%	NA	0%	NA	151.3	NA	NA	NA
	1984	6	17%	17%	17%	100%	17%	20%	183.3	NA	NA	0%
	1985	10	60%	50%	10%	17%	0%	NA	284.0	NA	68%	100%
	1986	4	75%	75%	0%	NA	0%	NA	359.0	NA	100%	NA
	1987	13	31%	31%	0%	NA	0%	NA	248.3	100%	100%	100%
	1988	23	17%	13%	4%	25%	0%	NA	168.5	100%	NA	87%
	1989	20	15%	5%	10%	67%	0%	NA	164.4	37%	NA	16%
	1990	14	0%	0%	0%	NA	0%	NA	191.7	NA	NA	NA
	1991	13	0%	0%	0%	NA	0%	NA	153.1	NA	NA	NA
	1992	24	25%	0%	25%	100%	0%	NA	107.2	0%	NA	0%
	1993	16	25%	13%	13%	50%	0%	NA	254.4	100%	NA	47%
	1994	6	33%	17%	17%	50%	0%	NA	237.7	100%	100%	0%
	1995	9	11%	11%	0%	NA	0%	NA	257.3	100%	NA	NA
LDT1	1981	9	11%	11%	0%	NA	0%	NA	244.4	NA	100%	NA
	1982	9	44%	44%	11%	25%	11%	20%	250.0	NA	54%	100%
	1983	16	50%	31%	19%	38%	0%	NA	258.8	100%	78%	43%
	1984	22	18%	23%	0%	NA	5%	6%	277.2	NA	100%	100%
	1985	23	39%	22%	17%	44%	0%	NA	305.0	100%	53%	38%
	1986	26	54%	46%	12%	21%	4%	8%	325.8	NA	NA	93%
	1987	29	76%	45%	31%	41%	0%	NA	280.3	90%	100%	65%
	1988	30	83%	70%	13%	16%	0%	NA	348.5	75%	NA	94%
	1989	29	93%	83%	10%	11%	0%	NA	372.9	100%	NA	94%
	1990	52	48%	19%	29%	60%	0%	NA	242.0	NA	NA	52%
	1991	45	47%	24%	22%	48%	0%	NA	252.8	NA	NA	57%
	1992	53	32%	21%	11%	35%	0%	NA	235.7	NA	NA	80%
	1993	56	30%	18%	13%	41%	0%	NA	280.1	100%	NA	73%
	1994	14	93%	86%	7%	8%	0%	NA	382.6	100%	98%	100%
	1995	20	80%	15%	70%	88%	5%	25%	159.3	0%	0%	24%
Car	1981	21	14%	10%	10%	67%	5%	6%	185.9	NA	34%	0%
	1982	31	19%	35%	0%	NA	16%	20%	266.2	100%	100%	NA
	1983	58	9%	7%	2%	20%	0%	NA	216.2	100%	100%	77%
	1984	98	29%	15%	13%	46%	0%	NA	249.7	100%	45%	74%
	1985	108	22%	19%	4%	17%	0%	NA	260.4	100%	93%	83%
	1986	64	0%	0%	0%	NA	0%	NA	167.5	NA	NA	NA
	1987	92	2%	2%	0%	NA	0%	NA	194.3	100%	NA	NA
	1988	80	16%	13%	8%	46%	4%	4%	301.5	100%	NA	60%
	1989	112	25%	18%	8%	32%	1%	1%	336.4	100%	NA	83%
	1990	91	23%	12%	11%	48%	0%	NA	268.0	NA	NA	63%
	1991	111	46%	27%	19%	41%	0%	NA	291.4	NA	NA	74%
	1992	90	76%	71%	4%	6%	0%	NA	355.1	NA	NA	99%
	1993	73	78%	75%	3%	4%	0%	NA	360.7	NA	NA	99%
	1994	74	77%	77%	0%	NA	0%	NA	365.7	100%	NA	100%
	1995	71	97%	18%	79%	81%	0%	NA	190.4	100%	0%	24%
	1996	1	0%	0%	0%	NA	0%	NA	372.0	NA	NA	NA
Total		1,778	38.8%	27.1%	12.5%	32%	0.8%	1.4%	267.9	85%	72%	77%